

Underwater Photographic Survey
of the "Proposed" Browns Ledge
Regional Dredge Spoil Dumpsite
Rhode Island Sound

by
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ERRATA SHEET

Photographs from Station 1: Brown's Ledge transect and Station I
Western Boundary of proposed Dump Site are reversed.

Omissions

Page 15, line 22deeper and connects with.....insert
after deeper "(pockets to 61 meters)".

Page 15, line 8 insert "and ^{or}submissible observations off Block Island
by McMaster et al. (1966)."

Page 25, paragraph 3 insert following last sentence. "Exploratory
dredgings made by Verrill (1871) identified the bottom
sediments as "mud" which contained many benthic invertebrates
known to occur at Brown's Ledge and Brenton Reef in similar
substrate."

ABSTRACT

Underwater photo coverage of the sediment-water interface, including photography of macrobenthos, was completed at ten stations within and around the proposed Browns Ledge disposal site. The survey was part of a Phase I study to determine the implications of the proposed disposal of an estimated 4 million cubic yards of dredge material from Fall River Harbor, Massachusetts, and future large-scale "regional" dumping of fine sediment in the study area. A total of thirteen dives was made in water depths ranging from 18.3 meters to 39.6 meters. The dives indicated that visibility is good, turbidity low, at least during the survey period. Coarse sediments and boulders of glacial origin predominate in the vicinity of the Ledge and along the western border of the study area. The sediments are poorly sorted but a decrease in grain size is apparent with increasing depth. Fine grain silt-clay and sand mixtures dominate the sea floor at depths of 36.6 to 39.6 meters in the extreme southern portion of the proposed dump area and sea floor immediately adjacent. The bottom here is sufficiently deep to be little affected by normal wave action and is characterized by considerable biological modifications. The benthos associated with these softer sediments consist of tube dwelling amphipods and polychaetes and deposit-feeding bivalves.

In comparison, broad sand waves and winnowed shell deposits observed peripheral to the Ledge area indicate a more dynamic

environment. The rock and boulder epibenthic assemblages were dominated by the filter feeding pink soft coral Alcyonium sp., sabellid worm Myxicola infundibulum, the burrowing coelenterate Cerianthus sp., Henricia starfish, and to a lesser extent Balanus sp. and sea anemones. Juvenile Henricia sanguinolenta (1-3cm diameter) were very numerous on surfaces of the larger rocks and boulders. The presence of gravid and juvenile Cancer irroratus and juvenile Homarus americanus indicates that the area holds some significance as a spawning and nursery area for these species.

Divers found ocean quahogs Arctica islandica at only one station but dredge sampling has shown that the species is distributed throughout. Cunner Tautoglabrus adspersus and eel pout Macrozoarces americanus were the dominant fish species seen. Further sampling is recommended to define the seasonal abundancies of benthos, lobster and groundfish species.

Introduction

On 16 May, 1973, the U. S. Environmental Protection Agency (EPA) issued ocean disposal criteria within which were designated seven ocean areas as "approved interim dump sites" for receipt of dredged material from New England waters. These were later reduced in number to five as follows: In Rhode Island Sound (a) the Acid Barge site, south of Block Island and (b) off Newport/Brenton Reef; Massachusetts Bay off Boston (c) the Foul Area and (d) Boston Light and in Maine (e) East Penobscot Bay off Isleboro. The sites represent discreet areas of the coastal zone where "regional" dumping will take place. This regional concept for ocean disposal was introduced in an effort to establish a regulatory program for offshore dumping grounds. The reduction in the number of disposal sites allows control of otherwise indiscriminatory dumping practices and facilitates environmental monitoring.

The Brenton Reef or Newport dumping grounds ($40^{\circ} 24' N$, $71^{\circ} 18' W$) was subjected to extensive studies of ecological effect of ocean disposal covering a four-year period from 1967 to 1970 (Saila, et al, 1972, Pratt, et al, 1973). However, continued use of this site has been hampered by legalities involving the deposit of dredge spoils from Massachusetts into Rhode Island. Further, mounting opposition and concern by

commercial fishing interests and conservationists over the possible deleterious effects of silt-laden waters attributed to the dumping and chemical qualities of the spoils have prompted a recent decision to close the grounds indefinitely. This action has resulted in the complete absence of an approved ocean dumping ground for the Rhode Island and southern Massachusetts area.

Subsequently, an area of one nautical mile square ($41^{\circ} 23' 25''$ N, $71^{\circ} 17' 58''$ W) located approximately one mile south of Browns Ledge has been recommended for study as an alternate regional dredge spoil disposal site (Figure 1). The selection of this site was made by the respective Departments of Natural Resources of the State of Rhode Island and the Commonwealth of Massachusetts (letters 18 and 21 February 1974). The site lies beyond the three mile state territorial waters and outside the Cape Cod and Islands Ocean Sanctuary.

Biologists/divers from the New England Division Corps of Engineers and the National Marine Fisheries Service, Woods Hole, conducted a cooperative reconnaissance diving survey of the proposed area during 5-7 and 10-11 June 1974. The principal objectives of the survey were (1) to assess by direct observations and photographic documentation seafloor conditions and associated epibenthos; (2) identify any commercially important shellfish or finfish population resources and (3) to determine the implications

Figure 1. Locations of the survey sites. The letters A, G, M, I and K denote the center and corner positions of the proposed disposal site and correspond to sediment-core sampling stations established by NED. The SCUBA stations attempted to approximate these five stations.

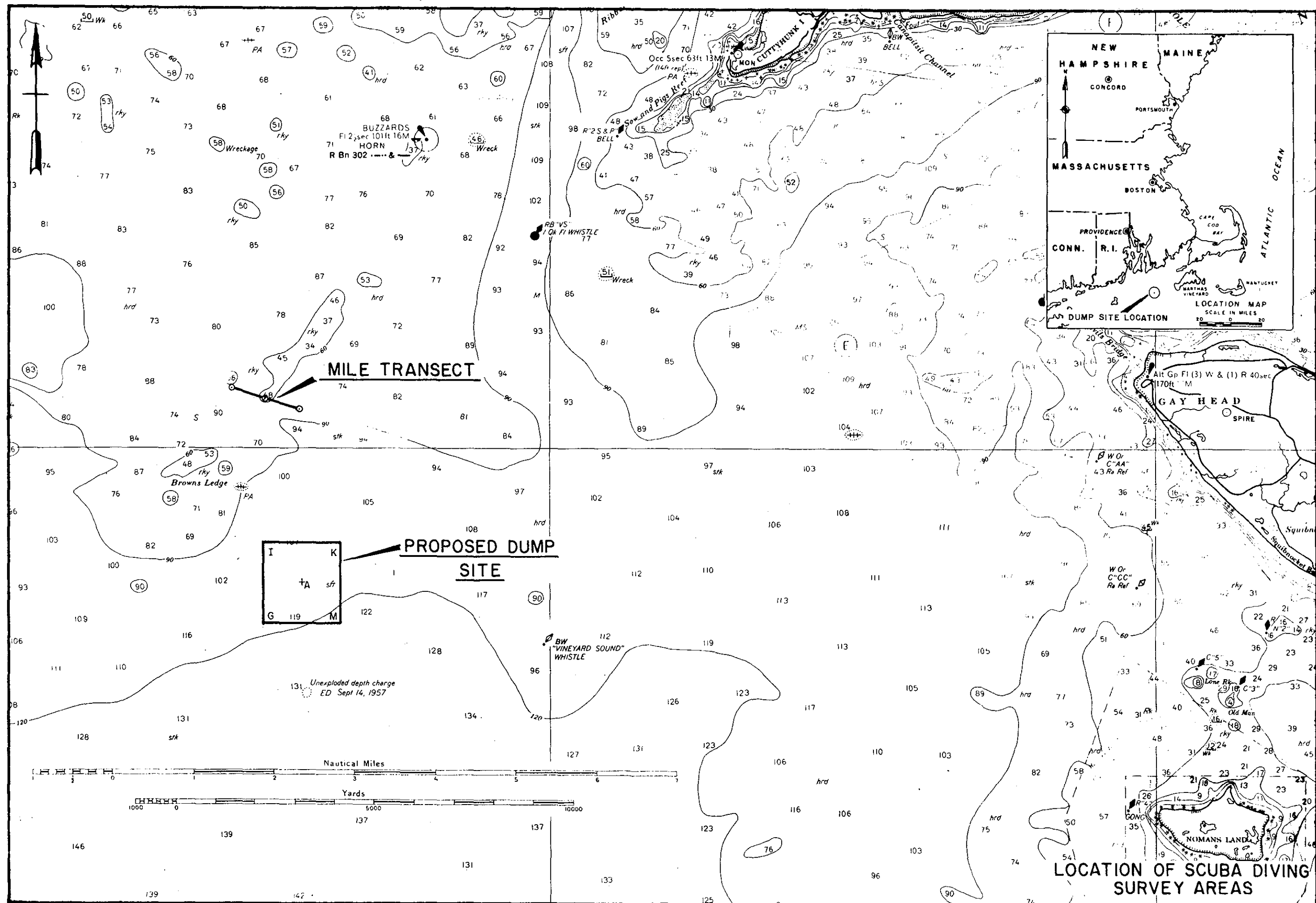


FIGURE 1

of the proposed disposal of dredge material on endemic fauna. The diving observations reported herein supplement results of biological dredge samples and sediment core analysis reported by Chase (1974).

Additional investigations are being undertaken or have been completed by the Corps as part of a comprehensive baseline research program. These studies include bathymetry profiles, biological dredge sampling and chemical and physical analyses of bottom sediments. The University of Rhode Island under contract to the New England Division Corps of Engineers is pursuing data collections on turbidity, current dynamics and benthic ecology. The studies are being carried out in accordance with Section 227.64, Environmental Protection Agency's Ocean Dumping Criteria (Federal Register 16 May and 15 October 1973) and Marine Protection, Research and Sanctuaries Act of 1972. The ultimate approval and formal designation of a new disposal site is delegated to the U. S. Environmental Protection Agency.

Description of the Project Area

Browns Ledge is situated some eight miles southwest of Cuttyhunk Island, Massachusetts, and approximately four miles south of the Buzzards Bay Light Tower. The Ledge consists of two submerged rock outcrops. Water depths covering the ledges, as indicated on Coast & Geodetic Survey Chart 1210, range from

10.4 meters to 16.1 meters. The ledges and associated glacial boulder-rock debris extend in a northeast-southwest direction for a distance of three miles. A deeper trough with depths from 21.3 meters to 32 meters bisects the ledges diagonally from northwest to southeast.

During the late 1950's the Atomic Energy Commission utilized Browns Ledge as an experimental site for simulated disposal of radioactive waste materials. Several cement-weighted 55-gallon drums filled with dye were discharged in 18.3 meters of water adjacent to the Ledge. Diver/scientists from the Bureau of Commercial Fisheries, Woods Hole (presently the National Marine Fisheries Service) and the Woods Hole Oceanographic Institution inspected and photographed the containers in-situ (D. Owens, WHOI, pers. comm.).

The study site lies within the Southern New England fishing grounds which comprise those waters extending from Great South Channel east of Nantucket to Montauk Point, New York. Seaward the grounds are bounded by the Continental Slope. This region constitutes statistical subarea 5 of the International Commission for the Northwest Atlantic Fisheries (ICNAF) which is responsible for management of fishery resources. Although commercial fishing activities occur throughout the area, the greatest fishing intensity is concentrated around several major banks or shoals. These include East Ground, Cox Ledge, Southwest Shoals, NOMANS

and Nantucket Shoals.

Personal interviews with local fishing representatives and scientists with the National Marine Fisheries Service, Environmental Assessments Division, Gloucester, Massachusetts, indicate that the Browns Ledge area supports commercial fleet operations from New Bedford, Westport, Cuttyhunk and Martha's Vineyard. Small trawlers from Point Judith and Newport, Rhode Island may also occasionally work the area. Cod, yellow-tail flounder, lobster and the ocean or "mahogany" quahog Arctica islandica are the major species of interest. However, commercially important foodfish are generally taken in small quantities and various industrial fish species provide the bulk of the catch.

Methods and Procedures

Prior to field operations two areas were selected for survey based on recommendations received from aforementioned state agencies and local fishing interests. These areas were (1) the nautical square mile area southeast of Browns Ledge and (2) the deep water trough area separating the Ledge proper. The latter location was suggested by Vineyard fishermen as a possible dispersal site for dredge material as the bottom is too rocky for trawling. A cruise track or transect paralleling the trough and extending for a distance of one nautical mile was determined by LORAN along its northern margin. Five dive

stations were established at equal distance along this transect. Individual stations were marked with an inflatable red-ball float, about 20-inch diameter, and anchor line. These buoy markers were left in place for the duration of the survey and served a dual purpose in facilitating relocation of the stations and safety orientation of the divers. In addition, a surface tender operating an inflatable Zodiac was deployed during actual diving operations as precautionary standby and tracking measures. This procedure was repeated at five dive stations within the proposed dump site area. These stations were chosen to correspond with specific coordinates delineating the study area as provided by the Rhode Island Marine Fisheries Division (letter, 21 March 1974). A staff buoy equipped with a reflector was set at the center location to insure position fixing accuracy. Some difficulties were encountered, however, and a discrepancy exists as to the exact center location of the dump site. Therefore, the dive station should be regarded as approximate to the coordinates given.

Single "bounce" dives of 8-12 minutes' duration were performed at each of the deep water stations. Somewhat longer dives of 17-25 minutes were made in the trough at Browns Ledge. The divers descended and ascended following the buoy line. One person was appointed diving supervisor to

maintain a close watch on bottom time and the whereabouts of the other divers.

The survey was carried out using standard open-circuit scuba equipment. All dives were scheduled so as to avoid decompression and therefore the sampling was, of necessity, confined to photographs and cursory observations. The personnel was divided into two diving teams which allowed alternation of dive assignments.

Repeated dives were made at Stations 1, 3 and 4 to conduct 25-meter line transect counts. Employment of this method allows a semi-quantitative evaluation of the epibenthos and consists of one or two divers swimming along the line noting the kinds and numbers of benthic biota and other pertinent ecological information within 1.5 meters to either side of the line.

Random underwater photographs, oblique and verticals, were obtained using Nikonos II cameras with 35mm lens and Subsea Mark 150 and 50 strobe light systems; closeup photographs were taken with a 3:1 extension tube. A metal frame attached to the lens provided a photo 9cm^2 area which enabled quantification of some smaller benthic invertebrate organisms. The photography provides a permanent documented record and allows identification of selected invertebrate forms, thus eliminating the need for actual specimen collections. Ektachrome High Speed 160 ASA film was used with regular 35mm lens and Ektachrome-X; 64 ASA exclusively for closeup strobe-illuminated photographs.

DESCRIPTION OF DIVER OBSERVATIONS
AND STATION LOCATIONS

Browns Ledge -- trough transect separating Ledge outcrops.

STATION 1 -- Northwest end of nautical mile transect located approximately four miles south of Buzzards Bay Tower, 55° compass course. Loran coordinates 3N4 6044.6 x 3N5 1604.3.

Diving Depth: Ranged from 75 to 85 feet (22.9-25.9 meters). Nineteen minutes total bottom time.

General Description: Bottom sediments varied from a compacted clay-silt mud to coarse sand and shell. Sand ripples, asymmetrical shape and measuring seven to eight inches in height and three feet apart, characterized the sand-shell type bottom. The topography was very level, being interrupted occasionally by relatively large ovoid depressions in the softer sediments.

Dominant Biota: Rock crabs Cancer irroratus; several adult size and many were berried females found burrowing into mud bottom. Some had dug quite deep into the compacted substrate.

Moon snail Polinices sp.

Plume worms, Myxicola infundibulum and Cerianthus sp. approx. 15-20/.1m².

Ocean quahog shells and fossilized oyster shells.

Bivalve Astarte sp.; few.

Sand flounder Lophopsetta maculata; 1.

Whiting or Silver Hake Merluccius bilinearis; 1.

Asterias vulgaris.

No lobsters or suitable lobster type habitat.

25 meter transect count -- 80 ft. depth; sand-mud bottom sediments.

Winter flounder Pseudopleuronectes americanus; 1/20-23 cm.

Hermit crabs Pagurus sp.; 10.

Cancer crabs C. irroratus; 3/adult 2 males, 1 female.

Ocean quahogs Arctica islandica; 2.

Moon snail Polinices sp.; 3.

Oyster shells; 4.

Starfish Asterias vulgaris; 1.

Leptasterias sp.(?); 1.
 Worm burrows/tubes; 150/.1m².
 Burrow holes 1/2 inch dia.; 4-6/.1m².

STATION 2 -- Loran coordinates 3N4 6050.0 x 3N5 1596.5.

Diving Depth: 84-90 feet (25.6-27.4 meters). Bottom time, 17 minutes.

General Description: Substrate consisted primarily of stone and gravel with an occasional boulder. A dusting of silt covered the bottom.

Dominant Biota:

Blue shark Prionace glauca; 1/2m.
 Spiny dogfish Squalas acanthias; 2/1-1.5m.
 Ocean Pout Macrozoarces americanus; 2.
 Radiated shanny Ulvaria subbifurcata; 2.
 Cunner Tautoglabrus adspersus; very abundant.
 Juvenile lobster Homarus americanus; 3.
 Cancer crabs C. irroratus; several juveniles.
 Bloodstar Menricia sanguinolenta; very abundant
 12-25 mm size on rocks.
 Common starfish Asterias vulgaris; few scattered.
 Soft coral Alcyonaria sp.; extremely abundant
 over rock surfaces.
 Plume worms Myxicola infundibulum and the burrowing
Coelenterate Cerianthus sp. were common and easily
 visible.

Hydroids formed abundant growths on the rocks and replaced the algae at these depths. A rust-colored coating appeared on several rocks and is thought to be either sponge or an encrusting species of bryozoan such as Schizoporella sp. Several burrows noticed under stone and rocks were found to inhabit small lobsters and cancer crabs.

STATION 3 -- Mid station of transect. Loran coordinates
 3N4 6052.9 x 3N5 1594.6. 42° compass bearing,
 approx. 4 miles south of Buzzards Bay Tower.

Diving Depth: 60-70 feet (18.3-21.3 meters). Bottom time, 25 minutes.

General Description: Shallowest dive station. Boulder and cobble pavement, visibility 15-25 feet.

Dominant Biota:

Coral Alcyonaria and red algae Phyllophora membrafolia sp. (4-7 cm height) covered the rocks. The algae in turn was encrusted with bryozoans and calcareous Spirorbis sp. worm tubes. Juvenile Menricia starfish up to 2-3cm diameter were very numerous on the rock surfaces. Balanus sp. (2-3 cm max. basal dia.) also were present in very dense concentrations. Other invertebrates observed included several sea anemones Metridium sp.; sponge colonies Halichondria sp. type on some rocks; and horse mussels Modiolus modiolus small size vertically between the rocks. A large mass of squid eggs (Loligo peali) found attached to the top-most surface of a boulder was photographed. Cancer crabs and several "short" lobsters were seen or uncovered by turning over rocks. Myxicola and Cerianthus species were common. Small piles of fecal castings were also seen. Excellent lobster habitat but no commercial size animals visible. Fish species were represented by cunner, ocean pout, cod Gadus morhua (1), and the radiated shanny (3).

25 meter line transect count -- 80 feet (24.4 meters); rocky, boulder substrate.

Cunner Tautoglabrus adspersus; hundreds in and around boulders.

Eel pout Macrozoarces americanus; 1.

Starfish Asterias vulgaris; 62.

Bloodstar Menricia; 2.

Soft coral Alcyonaria sp.; hundreds on rock surface.

Sabellid worms; 8.

Polychaete tubes; 15.

STATION 4 -- Loran coordinates 3N4 6056.5 x 3W5 1588.4.

Diving Depth: 80-85 feet (24.4-26 meters). Dive time, 12 minutes.

General Description: Wave-rippled sand bottom with occasional rock-boulder patches. Underlying substrate appeared to be compacted clay.

Dominant Biota:

Cunner Tautoglabrus adspersus; too numerous to count.

Spiny dogfish Squalas ascanthias; 2/1-1.2m.
 Lobster Homarus americanus; 2/juveniles.
 Cancer crabs C. irroratus; several.
 Porifera Polymastia sp.; Halichondria-like colony
 on one rock.
 Sea anemones; one large red species possibly Tealia
 sp. or Stomphia careola.

The cancer crabs and several lobsters had excavated burrows down into the clay. A rust-colored encrustation either Porifera or a Bryozoan was present on the rocks as described for Station 2.

25 meter transect -- Dive was actually made .7-1 nautical mile south of Station 4. Could not relocate #4 buoy due to severe fog conditions.

Diving depth 95 ft. (27.4m). Bottom time, 10 minutes. Survey restricted to the immediate area of the transect line. Bottom substrate consisted of rock, till, clay lumps, sand and occasional boulders. A large portion of the bottom adjacent to the rocky zone was etched by broad waves 6-7 ft. distance separating the crest with a very pronounced trough (35°-40° slope). Silt layer easily stirred up by divers which prohibited more detailed count.

Radiated shanny Ulvaria subbifurcata; 2.
 Cunner Tautoglabrus adspersus; 15.
 Sabellid worms; 10.
 Soft coral Alcyonaria; dense populations on rock as at Stations 2 and 3.

Lobsters and crabs absent but excellent habitat.

STATION 5 -- Marks ESE end of transect. Loran coordinates
 3N4 6058.6 x 3N5 1583.7.

Diving Depth: 90-95 feet (27.4-29 meters). Bottom time, 13 minutes.

General Description: Substrate fairly compact sand and mud with upper three or four inches fine silt. Occasional boulder and rocky area. Many burrow holes in the softer sediments and a few deep depressions or craters. Topography flat and although no waves or ripple marks were seen, a very weak current was detected. Worm and amphipod tubes and numerous burrow holes attested to biological reworking of the sediments.

Dominant Biota: Sedentary epibenthos of abundance included soft corals Alcyonaria sp.; several sea anemones Metridium sp. and one large dark red colored anemone (either Tealia or Stomphia species); Polymastia sponge and various hydroids and bryozoans.

The starfish Asterias and Henricia occurred in the same abundance and size range as encountered on previous dives. Cunnners, eelpout and red hake were observed with the former species dominating numerically. Scattered quahog shells were seen but no live specimens found. A long horizontal layer of bedded clay was exposed on one portion of the bottom. The clay contained many burrow holes and cave-like excavations, some of which were inhabited by C. irroratus. Other cancer crabs and juvenile lobsters had taken refuge among the rocks available.

Proposed Dump Area

STATION A -- Center of proposed one nautical square mile dump area, 41° 18'3" Lat. 71° 4'1" Long.

Diving Depth: 120 ft. (36.6 meters). Eight minutes total bottom time.

General Description: Surficial bottom sediments consisted of soft silty muds which were quite easily stirred up by the divers' swimming motions. The topography was very flat with little or no microrelief. Burrow holes, fecal castings and depressions contributed to the microrelief.

Dominant Biota: As the divers descended the buoy line, a four to five foot dogfish Squalus acanthias swam to within six feet of the lead diver, turned and swam back out of sight in the same direction. Pagurid crabs, cancer crabs and a few starfish Asterias vulgaris were the principal benthic forms. There were many ocean quahog shells but no live specimens were observed. Hydroids covered some of the shells and the gastropod Colus sp. was photographed. The bottom sediment was pitted with numerous small ($\frac{1}{4}$ to $\frac{1}{2}$ inch diameter) burrow holes and larger depressions made by an unknown source. The small burrow holes are estimated to number from 50 to 100 per meter square.

STATION M -- Southeast corner of the proposed dump area. Loran coordinates 3H5 1588 x 3H4 6045.

Diving Depth: 130 feet (39.6 meters). Bottom time, nine minutes.

General Description: Soft silt-clay mud bottom which exhibited considerable biological modification.

Dominant Biota: Epifaunal forms generally lacking. The common starfish Asterias vulgaris was the most conspicuous invertebrate species. A single dogfish was the only fish species encountered. The bottom evidences biological activity in the form of numerous burrow holes, tracks, fecal castings and amphipod tubes. Several deep depressions or pot holes as observed at Station A were present here also.

STATION G -- Southwest corner area. Loran coordinates 3H5 1600 x 3H4 6035.

Diving Depth: 125 feet (38.1 meters). Total bottom time, ten minutes.

General Description: Heterogeneous mixture of silt-clay muds, sand and rocky patches.

Dominant Biota: Cunnners Tautoglabrus adspersus were the most numerous fish species associated with the rocky areas. A few red hake Urophycis chuss about 14 to 16 inches in length occurred among the rocks. Colonies of the soft coral Alcyonaria sp. ranging from one-half to an inch in height were attached to the rocks along with hydroids and crustose bryozoans. One rock was coated with a rust colored sponge or Ascidian-like organism. Many burrow holes pitted the softer bottom sediments. Inspection of some of these holes revealed their inhabitants to be small cancer crabs, Cancer irroratus. Ocean quahog shells appeared scattered over the bottom but no live specimens were discovered. A few Asterias starfish were seen.

STATION I -- Northwestern corner area of proposed mile square dump site. Loran coordinates 3H5 1600 x 3H4 6038.

Diving Depth: 100 feet (30.5 meters). Total bottom time, twelve minutes.

General Description: Stone, rocks and occasional boulders. A dusting of silt covered the rocks.

Dominant Biota: Eelpout Macrozoarces americanus and cunners Tautoglabrus adspersus were common. The latter species existed in numbers too numerous to count. The little radiated shanny Ulvaria subbifurcata was a common burrow inhabitant under rocks and stones. "Short" lobsters were discovered in burrows under the rocks. Sessile benthic animals included sponge, bryozoans (both encrusting and erect forms), hydroids, and the soft coral Alcyonaria sp., some attaining fifteen or more colonies within a six-centimeter square. Small size Asterias observed to inhabit both soft and hard bottoms. Juvenile (1-2 cm dia.) Henricia starfish occurred on the rocks (3-6/2cm²). Conceivably the species could have been feeding on the coral colonies. No algae on rocks.

STATION K* -- Northeast corner area. Loran coordinates
3H5 1588 x 3H4 6045.

Diving Depth: 115 feet (35.1 meters). Total bottom time, eleven minutes. Divers descended and ascended URI's current meter-temperature sensor array buoy line.

General Description: Compacted mud (probably mixed clay-silt, sand) bottom. A flocculent surface layer of fine grained sediments exhibited bioturbation activities.

Dominant Biota: A single skate Raja sp. was the only fish life observed. Sabellid worms, four hermit crabs Pagurus sp., Asterias vulgaris, and one unidentified nudibranch species (one inch long) comprised the invertebrate epifauna. Numerous small burrow holes (50-60cm²) pitted the bottom sediments. Larger holes about 1/2 inch diameter constructed by an unidentified organism and numbering 5-6. Several conical-shaped burrows with an inverted entrance were found to contain crushed shell material but no inhabitant observed. Astarte sp. and Arctica islandica shells appeared irregularly. A pronounced thermocline existed near the bottom with temperatures noticeably colder compared to previous dives.

*This station location is in doubt as the URI's current arrays supposedly were set at the center and mid-way along the southern borderline.

Discussion

Sediment cover at Browns Ledge varies broadly from rocks and boulders to gravelly sand, sand and silt-clay muds. The nature of the substrate varied considerably from one station to another and even at a single location as exemplified by transect station 1. The deposits are typical of shelf relict sediments resulting from glacial erosion and deposition. Similar substrate type was previously described by Northrop (1951) in photographic transects through this same region. Core data obtained by NED from 21 locations within and adjacent to the proposed disposal site revealed sand as the dominant sediment type. Scattered boulders and rocks are found along the western border (Stations G and I).

There was a definite decrease in grain size with increasing distance to either side of the Ledge and seaward. Bathymetry profiles depict a very gradual sloping of the seafloor at the disposal site south into a shallow swale separating Browns and Cox Ledges. This swale is defined by the 36-meter contour line and contains depths to 45.7 meters (150 ft.) at some locations. The depression runs in an east-west direction and a few deeper pockets or holes exist off Block Island. Southward the trough becomes even deeper and connects with the Continental Slope. Dives at

the southern portion of the survey area substantiate the sediment core analysis and a greater accumulation of fine grains, silts and clays. Epibenthic organisms were limited to a few Paquid sp. crabs, Asterias starfish, and a gastropod Colus pygmaeus. The soft bottom evidences considerable signs of biological reworking with abundant animal tubes, fecal castings and various size burrow holes. The rocky communities were dominated by filter feeders, specifically corals Alcyonium sp., barnacles, tubeworm Spirobis borealis, the burrowing coelenterate Cerianthus and plume worms Myxicola infundibulum. Young of the year Henricia sanguinolenta were almost equal in number to the coral colonies.

Throughout the diving survey there was no clearly detectable currents nor excessive suspension of sediments. There was, however, a slightly noticeable near-bottom turbidity layer over the soft sediments at the deeper stations. Similar turbidity layers overlying silty bottoms at the mouth of Narragansett Bay and east of Point Judith were reported by Salla (1974). As indicated previously, the presence of sand waves and rounded gravels at the northern and central portions of the proposed dump ground indicates periodic reworking by waves and currents. The NOAA Atlantic Coast Pilot states that the currents for the general area are

rotary (clockwise) in nature. Such current systems are known to be subject to periodic variations and reversing currents. The establishment of a thermocline can create a marked difference between surface and bottom currents. At the time of the survey no thermocline existed although at Station I a much colder bottom water layer was felt by the divers. This colder density layer appeared to be quite localized as it was not experienced on other dives made the same day. Bottom currents detected by the U. S. Navy Systems Center (Shonting, 1967) ranged from 8.9 to 13.6 cm/sec. Surface speeds of from 20.8 to 24.1 cm/sec. were noted with a net flow WSW. Considerable variations were observed in the data in relation to the seasonal thermocline and a rotary tidal component was said to dominate bottom motion.

Ocean quahog Arctica islandica shells occurred at every station but live specimens were only found at Station 1. However, biological dredge samples obtained by the Corps show that quahogs are distributed throughout the area but in numbers too low to warrant commercial harvest. Exploratory surveys conducted by the National Marine Fisheries Service correlated the distribution of Arctica with a sandy bottom type or at least sediments with a high proportion of sand (Parker and McRae, 1970). The report further stated that

the species tends to concentrate in beds as opposed to being uniformly distributed. Dredge sampling conducted in May and September 1974 contained individuals or small numbers of quahogs. The largest catch consisting of 72 specimens was made in gray, sticky, clayey-sand towing west to east along the southern boundary line. The sampling results, however, are thought biased as problems were encountered with the hard bottom which prevented consistent tow time and penetration of the dredge.

Lobsters are considered the principal catch of value and are taken by both trap and trawl methods. The Browns Ledge area is potted primarily from June through September coinciding with the spawning season. Tagging experiments by Cooper and Uzmann (1971) identified summer migrations of offshore (slope) lobster stocks into the coastal fishing grounds. Historic tagging studies of lobsters in the vicinity of Woods Hole and the Elizabeth Islands (Bumpus, 1901) revealed a very positive westward movement. More recent tagging efforts by the Massachusetts Division of Marine Fisheries (letter, 20 January 1975) in Buzzards Bay and at Sow and Pig Reef off Cuttyhunk show that some individuals will move out into Rhode Island Sound. Most of the recaptures were made within the immediate release area but lobsters were recovered

from Southwest Shoals and three more taken at Hydrographer and Veatch Canyons. Such findings indicate that coastal lobster populations are equally capable of extensive travels. The seasonal migrations are temperature dependent and in Rhode Island Sound peak around late June or early July. The lobsters become vulnerable to trawl nets over the soft bottoms as they move into the Ledge area to molt and spawn. The rocks and boulders afford excellent protection and the sessile biota serve as a food source. Many juvenile lobsters had taken up residence in burrows beneath the rocky substrate. Undoubtedly, many more individuals could have been uncovered if a determined effort had been made.

Any change or degradation in the habitat may ultimately become a limiting factor in the distribution and abundance of lobsters (Saila, 1969). Thus the consequences of spoil disposal must be considered in light of its ecology as well as other resident benthic organisms.

Both rock and Jonah crabs Cancer irroratus and Cancer borealis were taken or observed. The former species appeared to be more numerous, however, and berried females were common. Cancer irroratus display an extended spawning season as egg-bearing females have been observed from January through July in Narragansett Bay and Vineyard Sound (personal observation). Krause (1972) reported capture of soft shell, egg-bearing

females at Boothbay Harbor in fall and winter months.

Numerous juvenile crabs (.5-1.5cm carapace width) were collected over medium and coarse sands in epibenthic sled tows on 6 September. Gravid Crangon septemspinosus and young Dichelopandalus leptocerus shrimp were very abundant in the same samples. Dichelopandalus are found over a wide depth range and sediments of varying quantities of organic matter (Wigley, 1960). This same shrimp and young cancer crab association was observed by divers at the Brenton Reef Dump later the same month.

Since the 1940's the southern New England fishing grounds, of which Browns Ledge is a part, has served primarily as an industrial or "trash fish" fishery. Red hake Urophycis chuss was the leading species and mainstay of the fishery through the Fifties (Sayles, 1951; Edwards, 1958). Historically, this area also served as the principal fishing grounds for yellowtail flounder Limanda ferriginea (Lux, 1964). In recent years, however, this species has suffered a drastic population decline, necessitating the establishment of catch quotas and area closures to protect the remaining spawning stocks. Species composition of industrial trawl landings for NoMans and "inshore" Point Judith grounds are presented by Edwards (1958) and Edwards and Lawday (1960). The distribution of fishing effort is often unpredictable

and varies both seasonally and annually depending upon natural migration patterns and species population fluctuations. Unfortunately, too, published information only shows the areas of greatest fishing intensity.

Eleven species of fish were observed during the survey but many of these were single sightings. The paucity of the fish fauna is attributed to the annual migration patterns exhibited by temperate demersal fish populations. During the warmer months they are found in fairly shoal waters but retreat to deeper offshore grounds in late autumn to feed or spawn until spring. The relationship between temperature and depth for several groundfish species captured on a survey transect from NOMANS to the Slope is given by Edwards et al (1962).

Numerically the cunner Tautogolabrus adspersus dominated. This species is a year-round resident of our coastal waters and is primarily an inhabitant of rocky areas where it feeds on various sedentary organisms (Bigelow and Schroeder, 1953).

A surprising find, not so much in its presence as its numbers, was the radiated shanny Ulvaria subbifurcata. Generally, this species is taken north of Cape Cod. However, divers noted the shanny at four stations (2, 3, 4 and I) where it was a burrow dweller among the stones. It was especially abundant at Station I in the northwestern corner.

Briggs (1974) has summarized records of its occurrence from Rhode Island and Block Island waters. Neither the cunner nor the shanny has any commercial or sportfish value but may serve as an important food chain component for larger demersal fish species.

The ocean pout Macrozoarces americanus were commonly seen solitary or in pairs under the larger rocks and boulders. This species is considered a potential marketable resource. Eel pout congregate and spawn during the fall over soft bottoms and a seasonal trawl fishery exists at the Browns Ledge area.

Spiny dogfish Squalus acanthias appeared at both the Ledge transect and dump site locations. One dogfish was being pursued by a blue shark which swam within a meter of the divers before veering away. Quarterly trawl surveys 1963-1966 showed the greatest abundance of dogfish during the fall season in a depth zone of 27-55 meters (Lux and Grosslein, 1970). In past years this species has made up the greatest portion of the catch from southern New England grounds and is taken year-round.

In summary, with the exception of the cunner, other species encountered were representative of dispersed populations.

Conclusions and Recommendations

The validity of the diving observations reported herein is limited to that time period only in which the survey was conducted. The data, however, when viewed collectively with the results of sediment-core analysis and biological dredge samples (Chase, 1974), provide enough evidence to permit a preliminary ecological appraisal at this time.

In terms of ecological quality the area supports a productive infaunal benthic community. Conversely, epibenthic assemblages did not appear to exhibit the diversity nor numbers observed at similar depths north of Cape Cod. Our transect counts and observations, however, should be regarded as only rough estimates of the true populations. Additional quantitative dredge and grab sampling is desirable for comparison of biomass and diversity values with those reported from Buzzards Bay, Long Island Sound and Gulf of Maine.

The presence of juvenile and gravid cancer crabs, gravid Crangon shrimp, non-commercial size lobster, and juvenile flounder indicates quite conclusively that the Ledge environment does serve as a spawning and nursery ground. The effects of turbidity and siltation will be more critical on attached organisms than on burrowing forms. Fine-grained dredged material is unsuitable for settlement of the larvae of many suspension or filter-feeding species. Therefore, the introduction of fine sediments into the gravel-sand and rocky zones

would be expected to downgrade this habitat type and associated bioassemblages. Dumping over the long-term will influence the ecological succession, recolonization rates and ultimately the degree of stabilization of the benthic populations.

The winnowed shell deposits and mixed relict sands and gravel sediment types reflect the glacial history of the North Atlantic shelf region. The diving observations and sediment data further indicate that the present location under consideration is more characteristic of a dispersal rather than a depositional type environment. Therefore, if containment of the dredged material is the primary objective (re: Proceedings of the Ocean Disposal Conference Woods Hole 1971 and EPA criteria), then disposal operations should be accomplished beyond the 36-meter (120 ft.) depth contour. This would require the relocation of the proposed dump area from approximately one to two miles further south, center to center. Here the fine-grain sediments are compatible with those characterizing "polluted" spoils as defined by EPA's criteria. Other favorable factors are the complete absence of scour or signs of currents which would insure relative containment of the dumped material, similarities in benthic fauna to that of Brenton Reef Dump Grounds area and the flat, featureless topography which facilitates monitoring of the spoil pile bathymetry.

Disposal operations, however, may conflict with commercial trawl fishing for lobsters and demersal fin-fish, particularly ocean-pout,

hake and flounder. Further sampling (pot, trawl and diving) is needed to document the natural seasonal cycles of these species populations against which the effects of dumping can be measured. Catch per tow data would provide a more reliable measure of species concentrations and biological value in terms of seasonal nursery grounds or feeding area.

Continued close coordination with appropriate regulatory agencies, particularly the National Marine Fisheries Service, in the selection of disposal grounds within the 12-mile contiguous zone and inner shelf waters is recommended. It would appear environmentally irresponsible, too, if the opportunity wasn't extended to island and mainland fishing interests to express their opinions on the proposed use of this ocean area.

With a view towards long-range planning for "regional" disposal action, serious consideration should be given to obtaining sediment cores and benthic grab samples from the deeper soft-bottom basin area south and west of the current study site. This will provide a data base for selecting an alternate site if needed and allow some built-in flexibility to the current decision-making process.

The organic carbon content of the sediments and dissolved oxygen levels of the bottom water should be determined. Both are limiting factors to the standing crop of benthos and are, therefore, important in establishing the site's load capacity and measuring post-dumping effects.

In order to facilitate relocation of the study area and for future research investigations, a permanent marker buoy should be placed at the center of the site. This will more easily allow for the establishment of sampling stations.

ACKNOWLEDGEMENTS

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Station 1: Browns Ledge transect - A and B. Seafloor photographs showing Pseudopleuronectes americanus and shells of Crassostrea virginia and Arctica islandica on coarse-grain sand. Shells are lying in trough of low, relatively broad ripple marks.

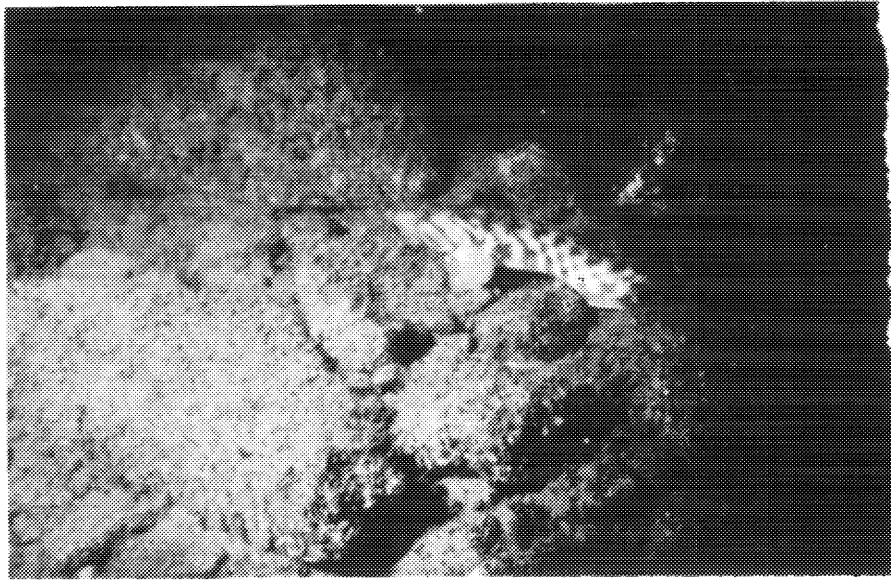


PHOTO A

STATION 1



PHOTO B

Station 1: C and D. Cancer irroratus and Polinices sp. on compacted silt-clay bottom proximal to photos A and B. The sediment cloud produced by the cancer crabs indicate soft, fine grain size of the surface sediments.

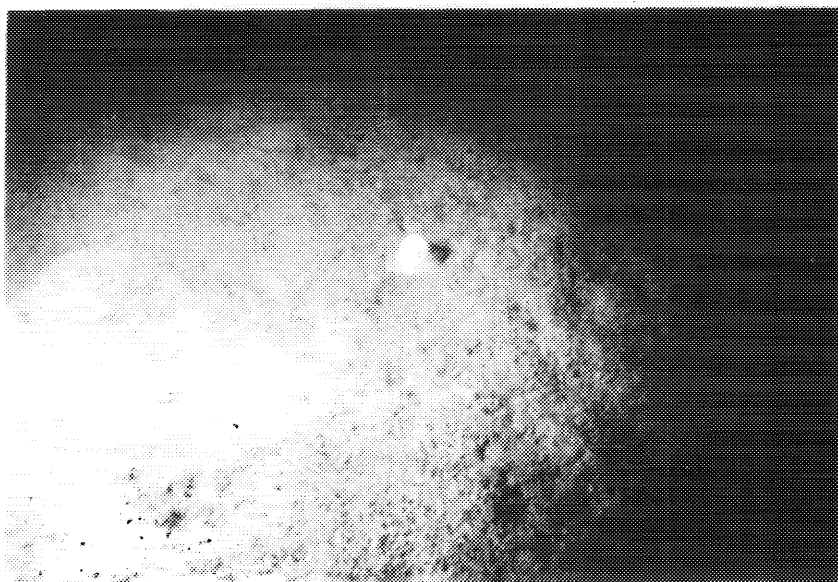


PHOTO C

STATION 1

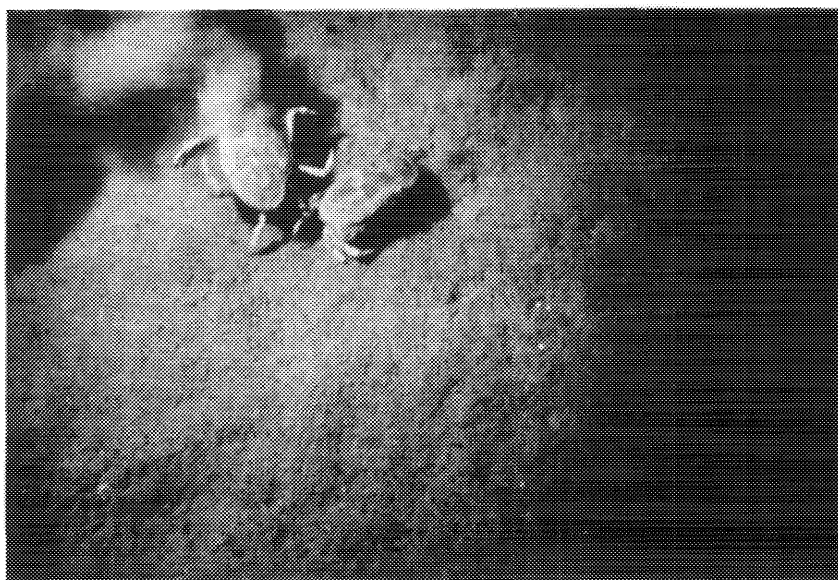


PHOTO D

Station 2: Browns Ledge transect - A. Sea stars Asterias vulgaris on cobble pavement (27m depth). B. Actinoid corals, hydroids, numerous juvenile Henricia, Macrozoarces americanus and Tautoglabrus adspersus comprise benthic community associated with glacial boulders and rocky bottom.



PHOTO A

STATION 2

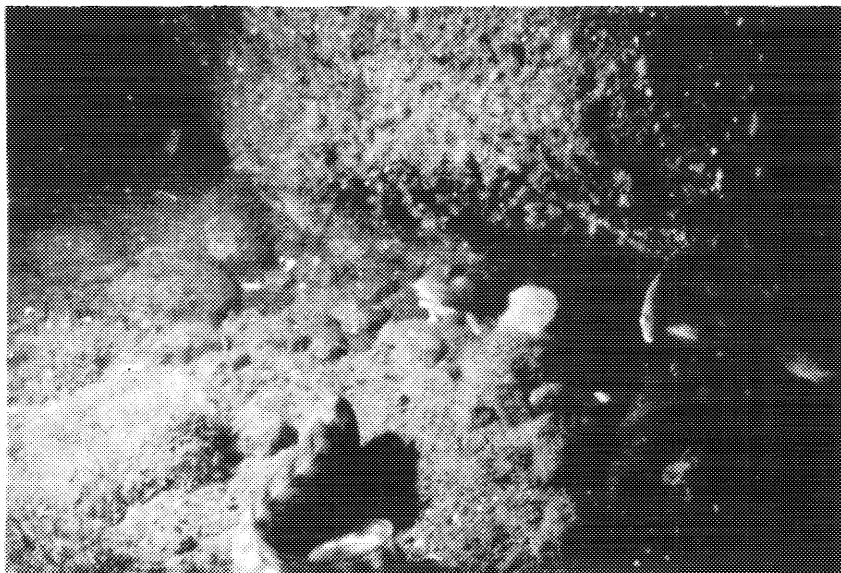


PHOTO B

Station 3: Browns Ledge transect - A and B. Rock and cobble substrate supporting heavy growth of the red algae Phyllophora membranifolia and soft corals. A Macrozoarces americanus warily eyes diver's approach.



PHOTO A

STATION 3

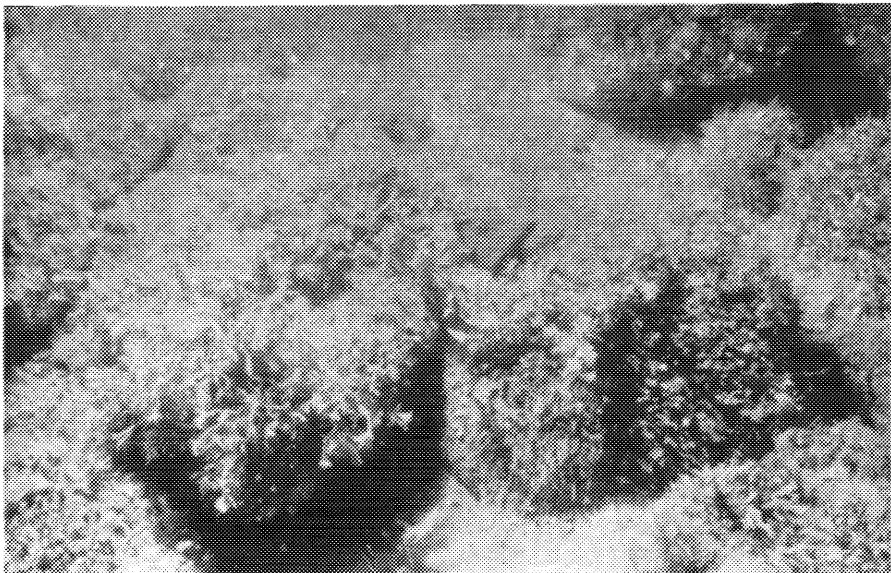


PHOTO B

Station 4: Browns Ledge transect - A. Wave-rippled sand bottom. B. Closeup of sessile rock community dominated by Metridium and Actinoid corals. C. Scattered rocks, one with an unidentified sea anemone, on sand-rippled bottom. D. Rocks and boulder showing attached Actinoid corals and Tautoglabrus adspersus.

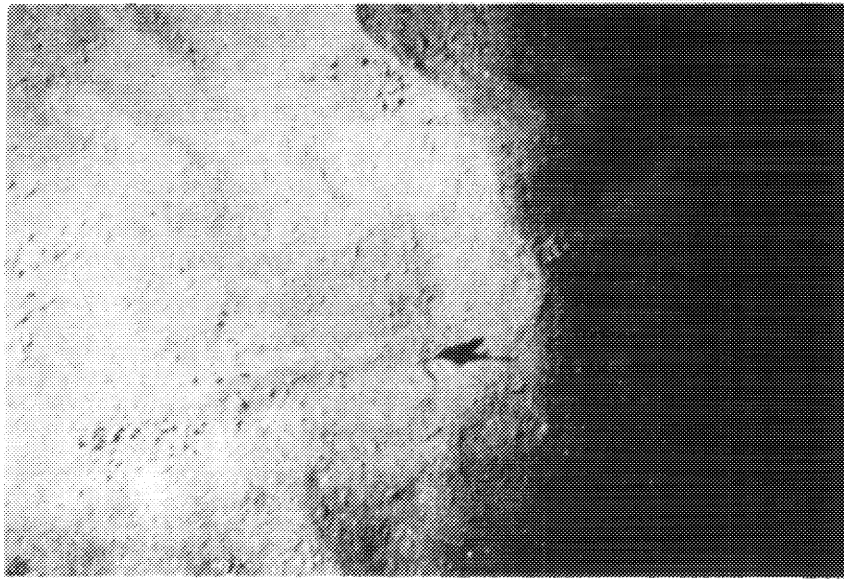


PHOTO A

STATION 4

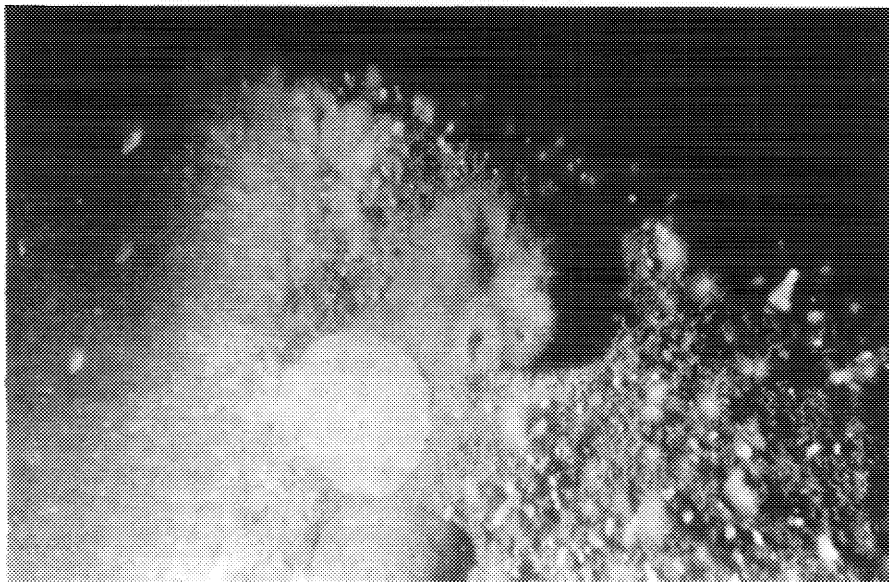


PHOTO B

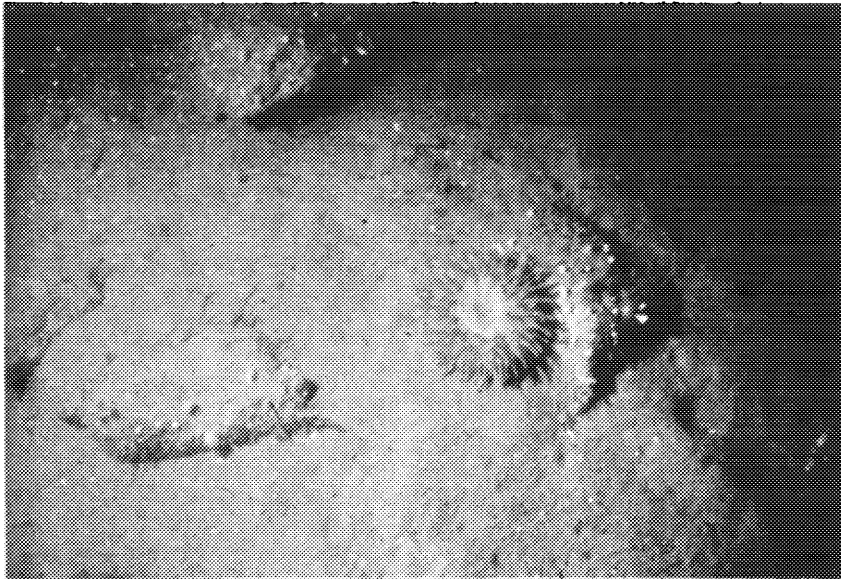


PHOTO C

STATION 4

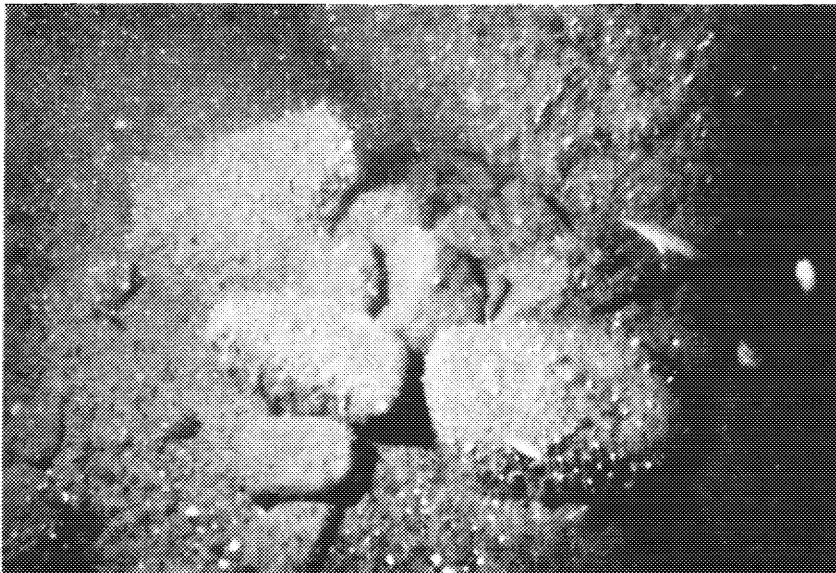


PHOTO D

Station 5: Substrate and benthos observed during dives Browns Ledge transect. A. Compacted sand and mud display a complete absence of epifauna but evidencing signs of productive infaunal community through the presence of burrow holes. B. Closeup of exposed layer of compacted clay which has undergone extensive tunneling and burrowing by cancer crabs and juvenile lobsters. C and D. Rock and gravel sediments with associated attached fauna including hydroids, soft corals, juvenile sea stars Henricia and an unidentified large orange-red colored sea anemone. Cunnners Tautoglabrus adspersus swim in the background.

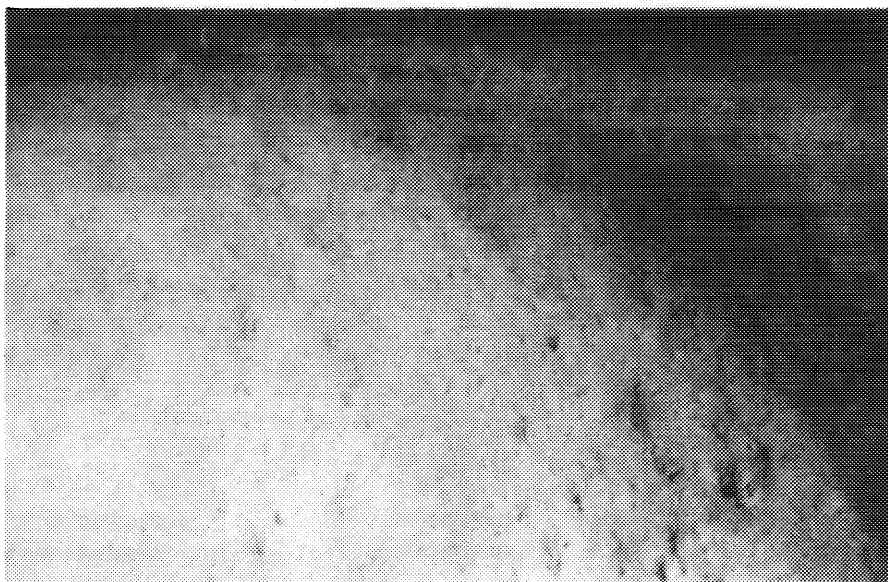


PHOTO A

STATION 5

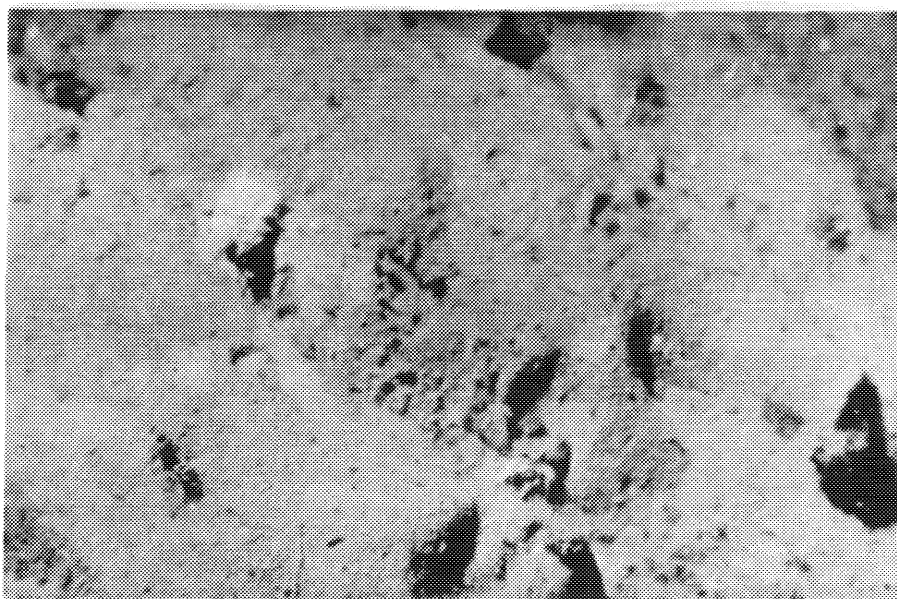


PHOTO B



PHOTO C

STATION 5

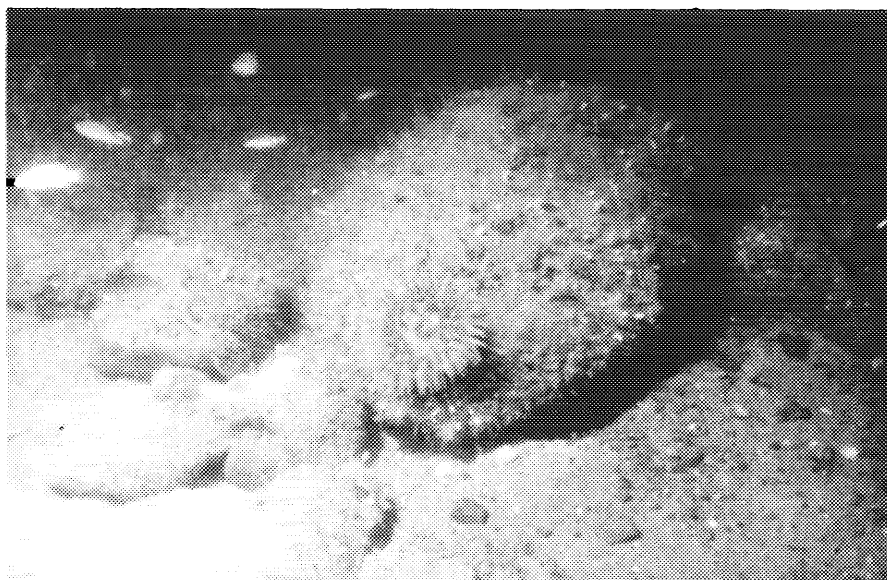


PHOTO D

Station 5: Browns Ledge Transect - E and F. Rocky bottom with hydroids and pink soft coral *Alcyonaria* attached. A school of cunners *Tautoglabrus adspersus* circle around the diver feeding on food items uncovered or suspended by the diver's swimming motion.

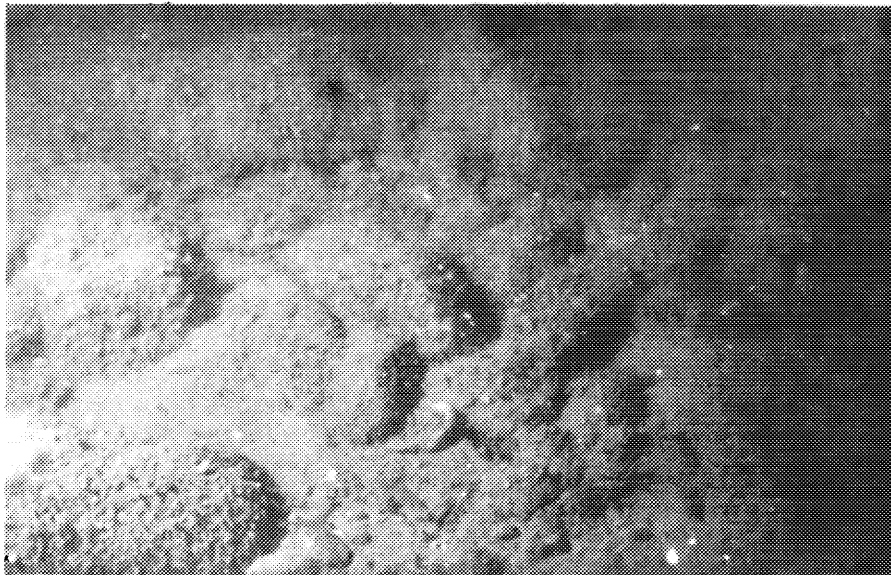


PHOTO E

STATION 5



PHOTO F

Photographs of proposed dump site Browns Ledge. Central portion of site - A. Surficial sediment of silty mud reveals burrow holes and Arctica islandica valves. B. Excavations of unknown origin but possibly made by cancer crabs. Sides of burrows show amphipod tubes which act to trap and bind the sediment.

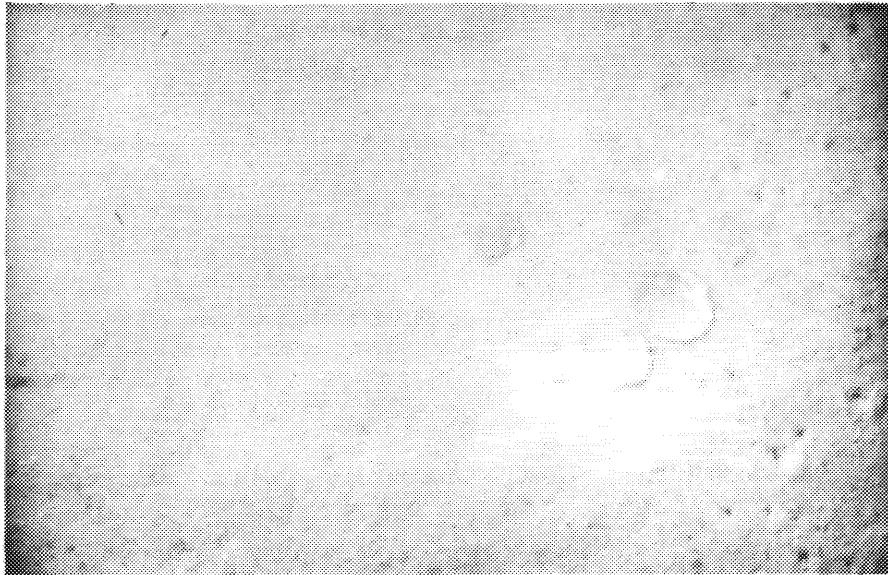


PHOTO A

CENTRAL PORTION OF SITE



PHOTO B

Photos of seafloor proposed dump area in vicinity of southeast corner (39m). A. Dense concentration of animal tubes projecting above sediment surface. B. Shallow excavation approximately 60-80cm length thought to be created by Lophius americanus.

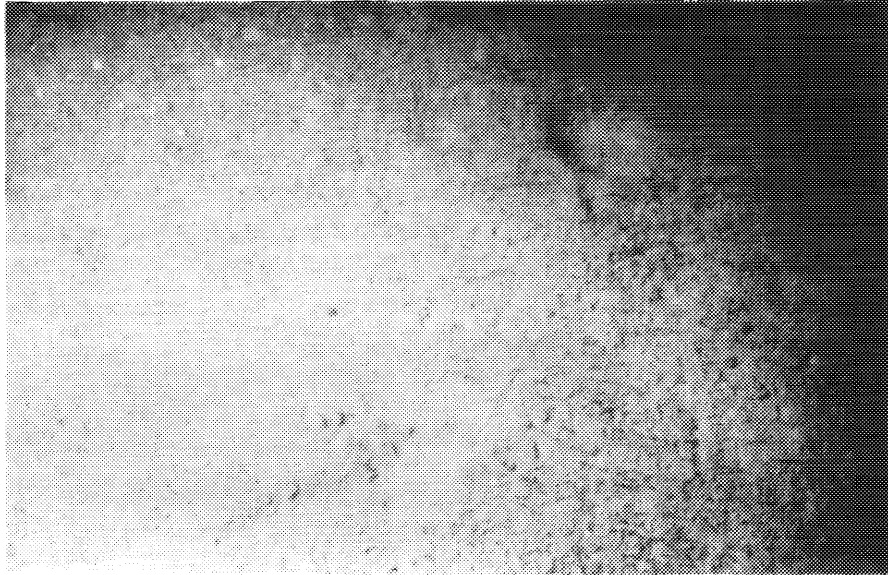


PHOTO A

VICINITY OF SOUTHEAST CORNER

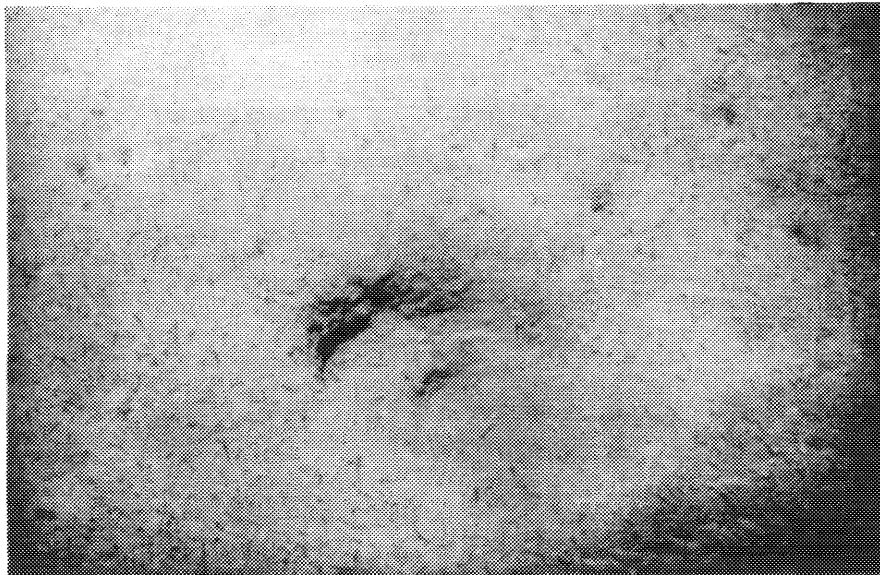


PHOTO B

Station I: Along western boundary of proposed dump area.
A. Macrozoarces americanus among rock and boulders. B. Shell,
stone and sand bottom at base of boulder. Henricia sanguinolenta
and hydroids characterize the boulder surface.

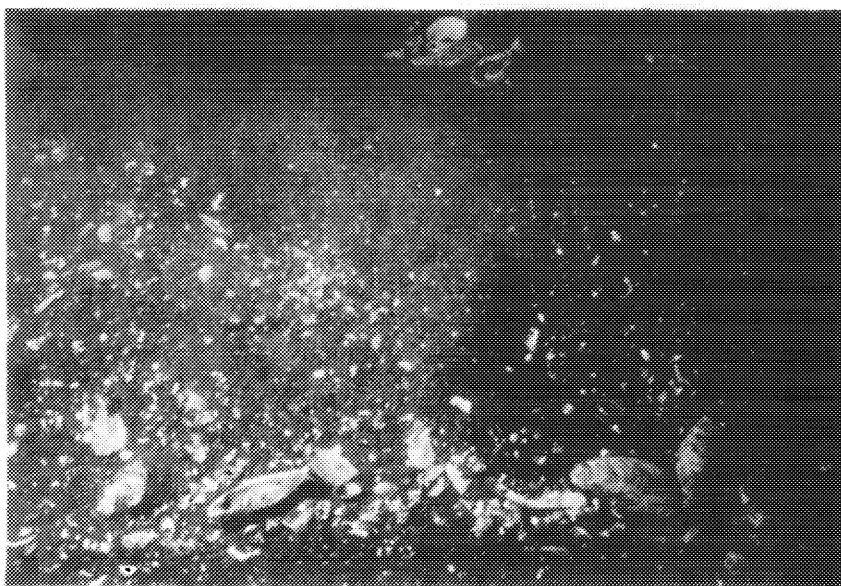


PHOTO A

STATION I

WESTERN BOUNDARY

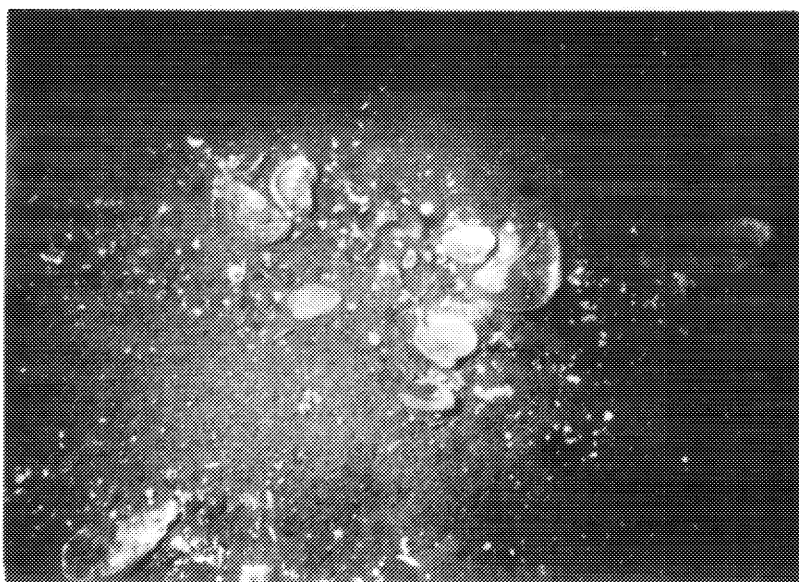


PHOTO B

Examples of biological modification of sediments in proposed dump area along eastern border. A. Raja sp. (50-60cm) on compacted mixture of clay-silt and sand bottom. B. Numerous holes, animal tubes and excavation probably made by a cancer crab. Mats of amphipod tubes are seen hanging loosely around rim of the larger burrow.

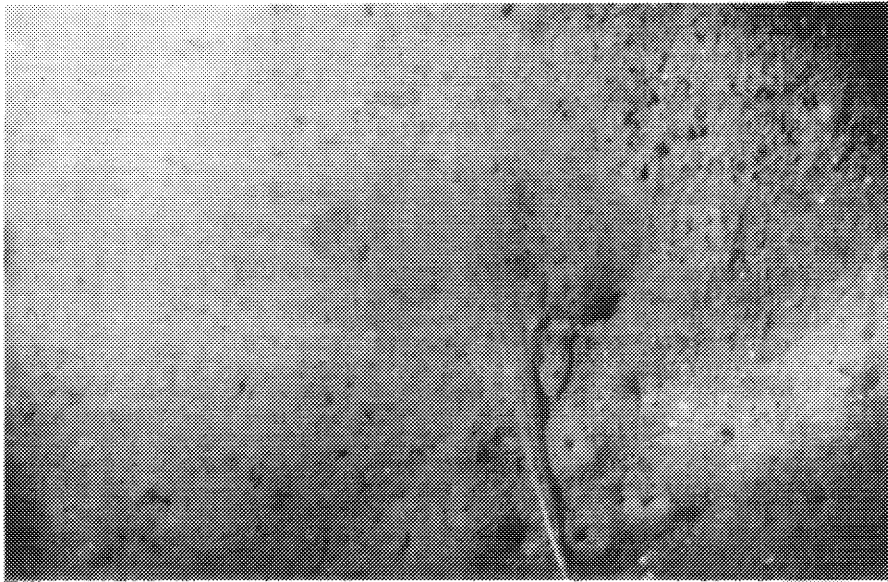


PHOTO A

PROPOSED DUMP AREA ALONG EASTERN BORDER

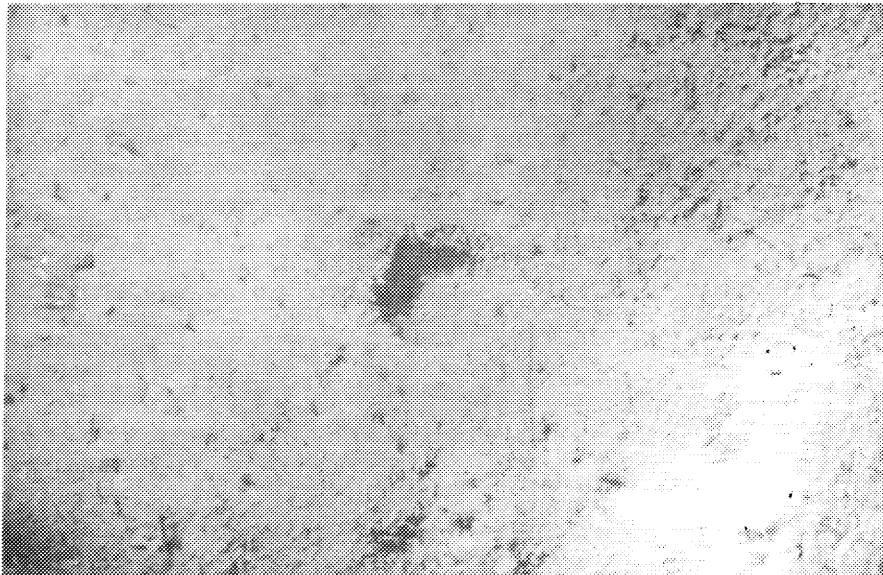


PHOTO B

Vicinity of southwest corner (G). Depth 38 meters. Substrate varied from rock and gravel to sands and silt-clay mud. Arctica islandica shells are scattered on the bottom.

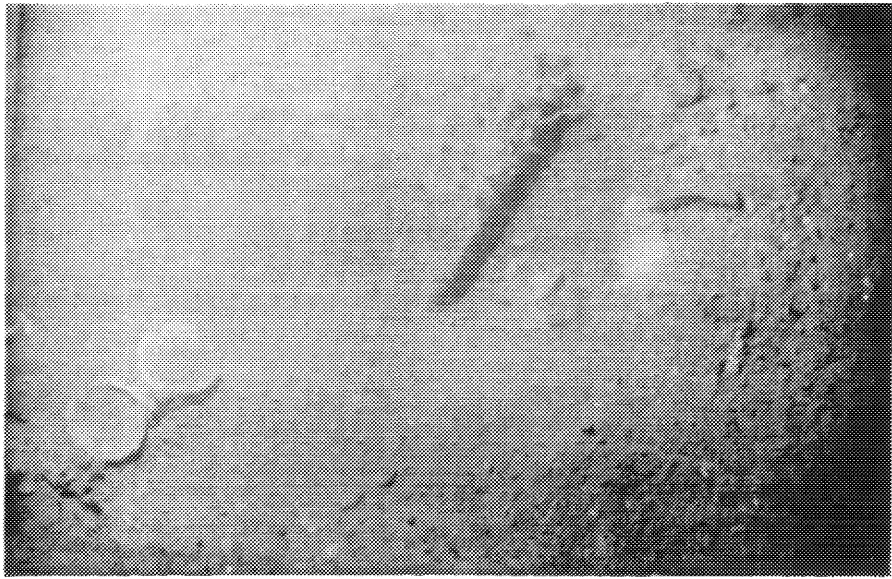


PHOTO A

SOUTHWEST CORNER

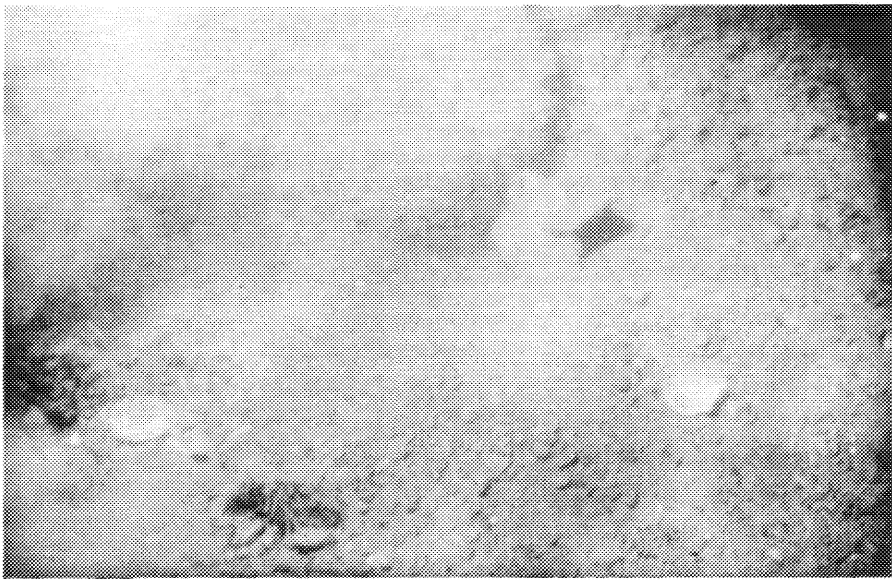


PHOTO B